

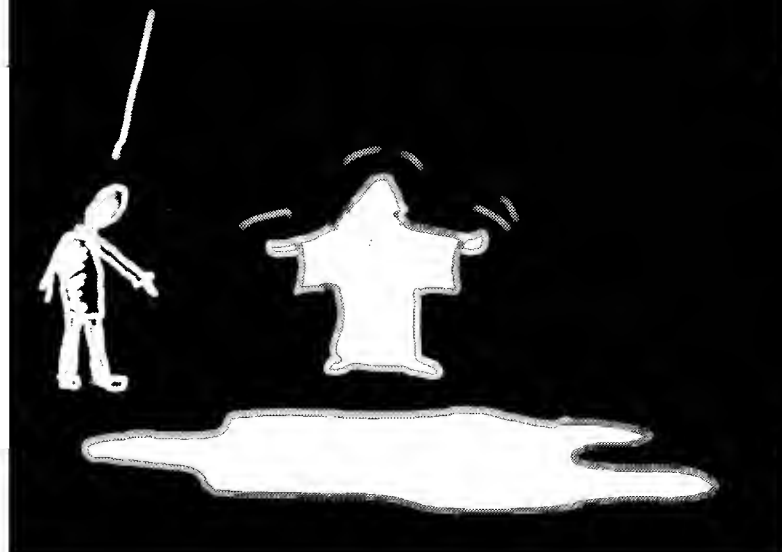
UH... WE'VE BEEN WALKING THE
WRONG DIRECTION FOR ALMOST
AN HOUR...I NEED TO GET HOME!
I HAVE A TEST TOMMORROW!



DON'T WORRY. YOU'LL BE BACK
IN TIME FOR YOUR TEST. ANYWAY,
WE'RE HERE!



WE WALKED AN HOUR TO SEE A
MUD PUDDLE?



MUCH MORE THAN THAT!



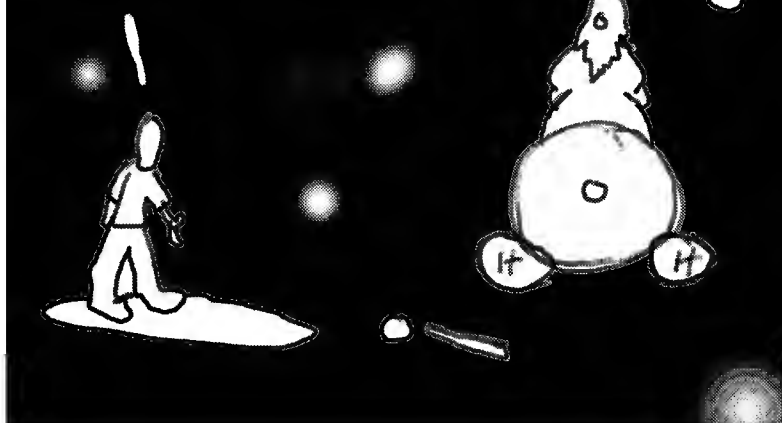
WHAT THE...?



WHY AM I FLOATING ON A DISC?

SO YOU DON'T FALL FOR
ALL INFINITY?

OH, OK.



WITHOUT WATER, LIFE CAN NOT EXIST.
THE QUESTION IS.. WHY WATER?

IN ORDER TO ANSWER THIS THIS QUESTION,
WE NEED TO UNDERSTAND A LITTLE BIT OF
BASIC CHEMISTRY FIRST.

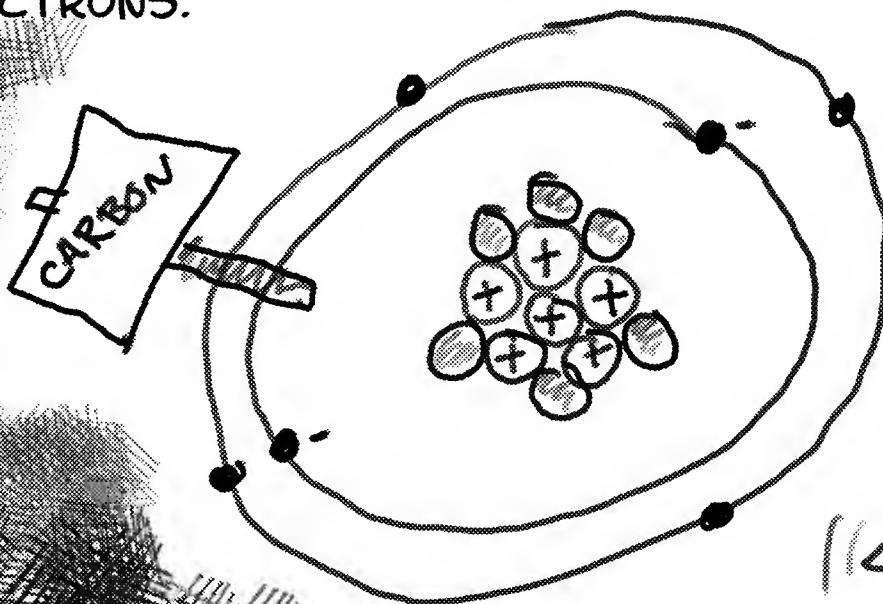
ATOMS: ATOMS ARE THE
SMALLEST UNIT OF AN ELEMENT.
IN BIOLOGY, THERE ARE ONLY A HANDFUL
OF ELEMENTS THAT WE CARE ABOUT:

SULFUR, PHOSPHORUS, OXYGEN, NITROGEN,
CARBON AND HYDROGEN (SPONCH)
MAKE UP 99% OF LIVING THINGS.



HERE - LET'S TAKE A LOOK AT AN ATOM UP CLOSE:

THIS IS CARBON, THE MOST IMPORTANT ELEMENT FOR LIFE.
IT IS MADE UP OF THREE PARTS: PROTONS, NEUTRONS AND
ELECTRONS.



⊕ = PROTON
⊙ = NEUTRON
• = ELECTRON



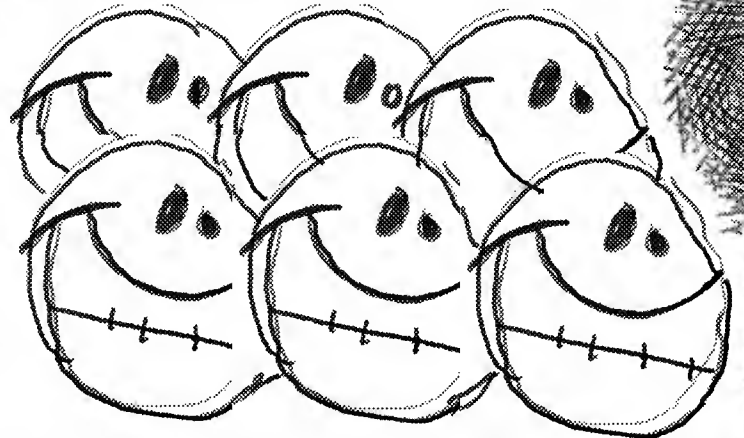
DISC OUT OF CONTROL!
GONNA PUKE!

PROTONS HAVE A POSITIVE CHARGE, JUST LIKE THE PLUS END OF A BATTERY. THEY HANG OUT IN THE NUCLEUS, IN THE CENTER OF THE ATOM. THE NUMBER OF PROTONS IN AN ATOM DEFINES THE ELEMENT. CARBON, FOR EXAMPLE, ALWAYS HAS 6 PROTONS.

VERY
POSITIVE
PROTON

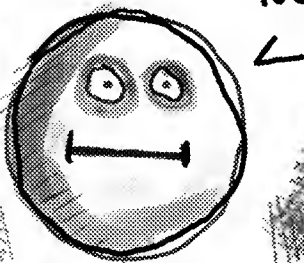


CARBON



ALSO IN THE NUCLEUS ARE NEUTRONS. THEY HAVE ABOUT AS MUCH MASS AS PROTONS, BUT THEY DON'T HAVE A CHARGE. THE NUMBER OF NEUTRONS CAN VARY FROM ATOM TO ATOM. MORE ON THAT LATER

NOTHING EXCITES ME. EXCEPT DUBSTEP



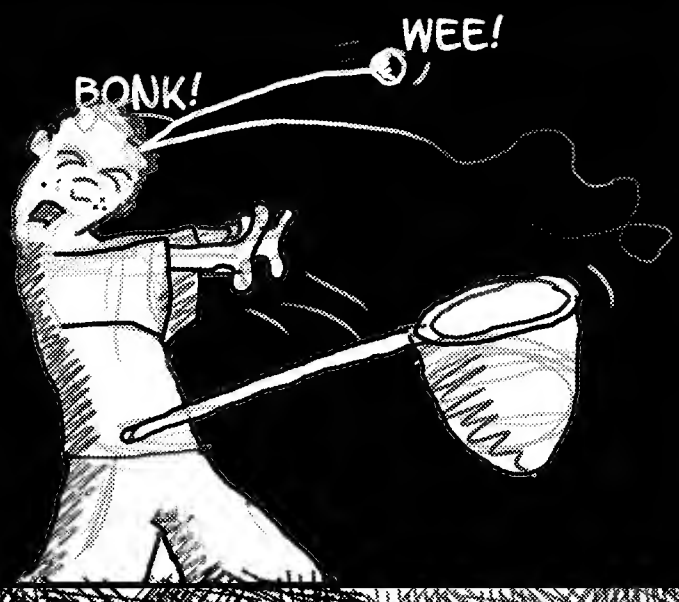
LASTLY WE HAVE ELECTRONS. THEY ARE HYPERACTIVE LITTLE BUGGERS THAT ORBIT AROUND THE NUCLEUS. THEY HAVE A NEGATIVE CHARGE, BUT VIRTUALLY NO MASS... MAKES THEM VERY HARD TO CATCH!

EASY.... EASY...



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BONK!



YOU CAN TELL SOME THINGS ABOUT AN ATOM BY LOOKING A PERIODIC TABLE LIKE THIS:

1 H 1.008	2 He 4.003
3 Li 6.941	4 Be 9.012
5 B 10.81	6 C 12.011
7 N 14.007	8 O 15.999
9 F 18.998	10 Ne 20.180
11 Na 22.990	12 Mg 24.305
13 Al 26.982	14 Si 28.086
15 P 30.974	16 S 32.06
17 Cl 35.45	18 Ar 39.948
19 K 39.098	20 Ca 40.078
21 Sc 44.956	22 Ti 47.88
23 V 50.942	24 Cr 51.996
25 Mn 54.938	26 Fe 55.845
27 Co 58.933	28 Ni 58.69
29 Cu 63.546	30 Zn 65.38
31 Ga 69.723	32 Ge 72.64
33 As 74.922	34 Se 78.96
35 Br 79.904	36 Kr 83.80
37 Rb 85.468	38 Sr 87.62
39 Y 88.906	40 Zr 91.224
41 Nb 92.906	42 Mo 95.94
43 Tc 98.906	44 Ru 101.07
45 Rh 102.91	46 Pd 106.90
47 Ag 107.87	48 Cd 112.41
49 In 114.82	50 Sn 118.71
51 Sb 121.76	52 Te 127.60
53 I 126.91	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33
57-70 Lanthanide series	71 Lu 174.967
72 Hf 178.49	73 Ta 180.948
74 W 183.84	75 Re 186.207
76 Os 190.23	77 Ir 192.225
78 Pt 195.084	79 Au 196.967
80 Hg 200.59	81 Tl 204.38
82 Pb 207.2	83 Bi 208.98
84 Po 209	85 At 210
86 Rn 222	87-102 Actinide series
89 Fr 223	90 Ra 226
91 Ac 227	92 Th 232.038
93 Pa 231.036	94 U 238.029
95 Np 237.048	96 Pu 244.064
97 Am 243.061	98 Cm 247.070
99 Bk 247.070	100 Cf 251.083
101 Es 252.083	102 Fm 257.105
103 Md 258.10	104 No 259.108
105 Nh 261.109	106 Fl 269.109
107 Ts 278.107	108 Og 284.116
109 Uu 289.101	110 Uub 293.104
111 Uut 288.106	112 Uub 285.108
113 Uuh 284.107	114 Uuq 289.103

57 La 138.905	58 Ce 140.12	59 Pr 140.908	60 Nd 144.24	61 Pm 144.913	62 Sm 150.36	63 Eu 151.964	64 Gd 157.25	65 Tb 158.925	66 Dy 162.50	67 Ho 164.930	68 Er 167.259	69 Tm 168.930	70 Yb 173.054
91 Ac 227.033	92 Th 232.038	93 Pa 231.036	94 U 238.029	95 Np 237.048	96 Pu 244.064	97 Am 243.061	98 Cm 247.070	99 Bk 247.070	100 Cf 251.083	101 Es 252.083	102 Fm 257.105	103 Md 258.10	104 No 259.108

* Lanthanide series

** Actinide series

IF WE LOOK SPECIFICALLY AT OUR FRIEND CARBON AGAIN, WE SEE 3 THINGS:

ATOMIC NUMBER

ATOMIC SYMBOL

ATOMIC MASS

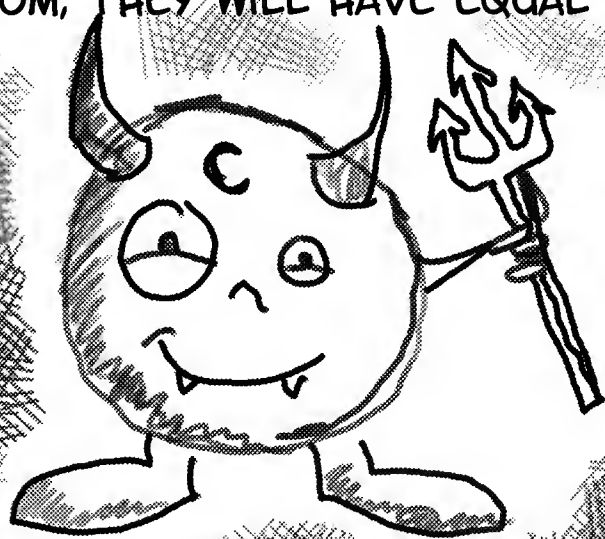
6
C
12.011

Booyah Boron.

Ug.

ATOMIC NUMBER IS HOW MANY PROTONS THAT ELEMENT HAS. CARBON IN THIS CASE HAS 6. THE ATOMIC SYMBOL IS JUST HOW IT IS WRITTEN. LASTLY, WE HAVE ATOMIC MASS, PROTONS AND NEUTRONS BOTH HAVE A MASS THAT IS CLOSE TO 1, SO IN BIOLOGY, WE CAN JUST CALL IT 1. THEREFORE, SINCE CARBON HAS HAS A MASS OF ABOUT 12, AND 6 PROTONS, WE CAN FIGURE OUT THAT IT MUST HAVE 6 NEUTRONS AS WELL. IN AN NON-CHARGED ATOM, THEY WILL HAVE EQUAL NUMBERS OF ELECTRONS AS PROTONS TOO.

6 Protons
6 Neutrons
6 electrons
umm...



NOW, YOU MIGHT HAVE NOTICED THAT CARBON HAS AN ATOMIC WEIGHT NOT OF 12 EXACTLY, BUT OF 12.011.

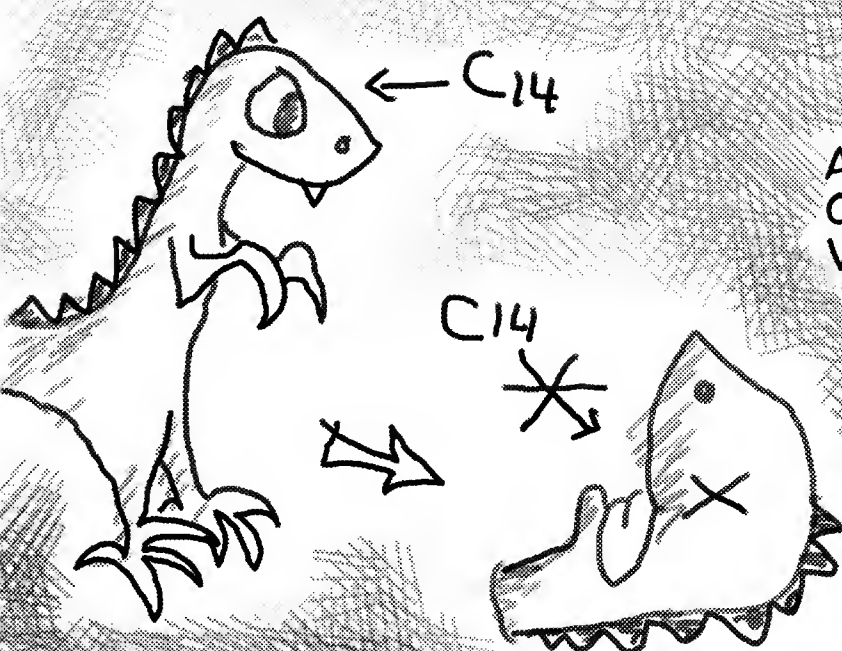


I WOULD HAVE... HAD I NOT JUST THROWN UP ON THE PERIODIC TABLE.

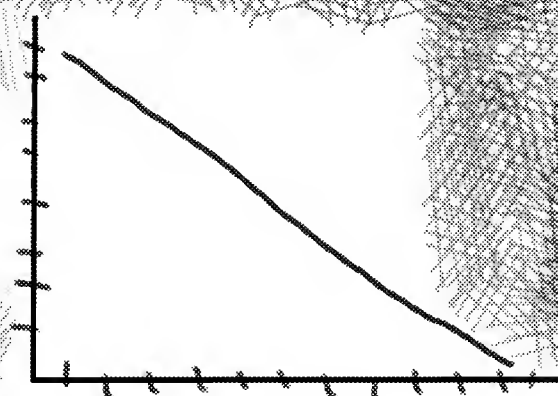
OH, GROSS. THIS DIFFERENCE IS PARTLY BECAUSE IT IS AN AVERAGE MASS OF ALL THE ATOMS OF CARBON KNOWN. SOME OF THESE ATOMS HAVE GREATER OR FEWER NUMBERS OF NEUTRONS. THESE ARE KNOWN AS ISOTOPES, AND THEY ARE USUALLY UNSTABLE AND FALL APART AT A PREDICTABLE RATE.



LIVING THINGS TEND TO TAKE IN LOTS OF A PARTICULAR ISOTOPE CALLED CARBON 14 (HAS 2 EXTRA NEUTRONS). WHEN THEY DIE, THAT CARBON 14 CEASES TO BE TAKEN IN, AND WHAT IS LEFT STARTS TO FALL APART AT A PREDICTABLE RATE. THIS ALLOWS US TO CARBON DATE THINGS THAT WERE ONCE ALIVE TO TELL WHEN THEY DIED.



AMOUNT
OF C14
VS C12

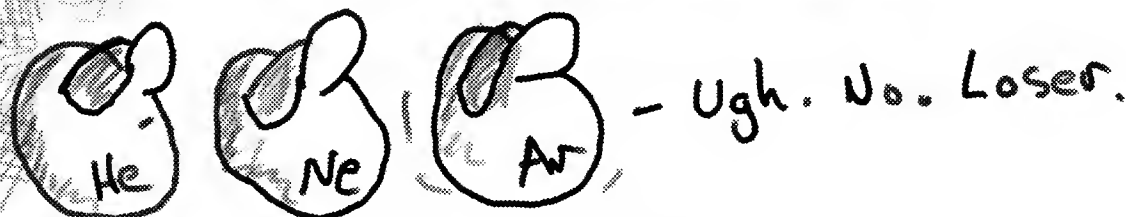


HOW LONG ITS BEEN DEAD

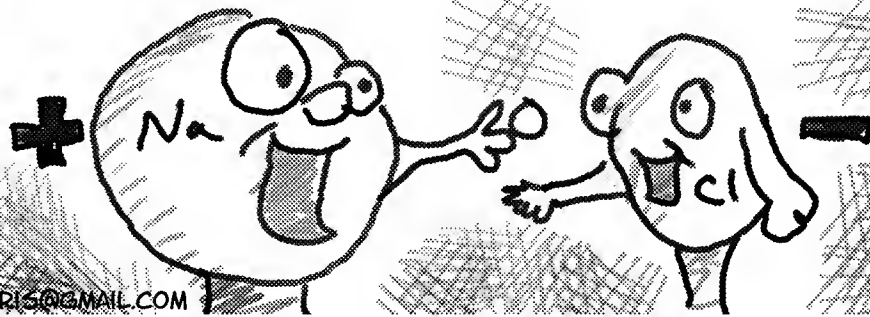
SO HOW THEN DO ATOMS STICK TOGETHER TO FORM MOLECULES? WELL, I'M GLAD I ASKED MYSELF THAT. YOU SEE, MOST ATOMS AREN'T 100% HAPPY WITH THEMSELVES. THEY ARE LOOKING FOR SOMETHING, SPECIFICALLY EITHER TO GAIN OR LOSE SOME ELECTRONS.



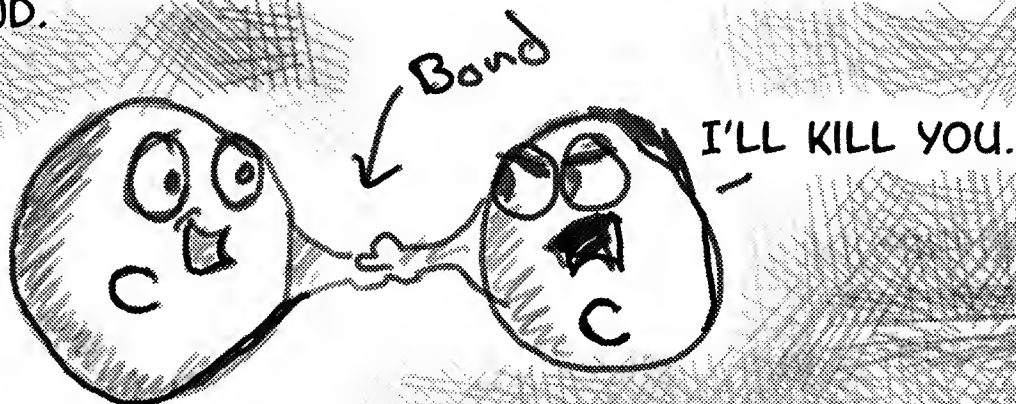
EACH ELEMENT WANTS TO GAIN OR LOSE A CERTAIN NUMBER OF ELECTRONS. THE NOTABLE EXCEPTION BEING THOSE SNOOTY, UPPITY NOBLE GASES IN THE RIGHT HAND COLUMN OF THE PERIODIC TABLE. THEY HAVE ALL THE ELECTRONS THEY WANT, SO THEY DON'T HANG OUT WITH ANYBODY ELSE.



NOW, IF AN ATOM THAT REALLY WANTS AN ELECTRON MEETS UP WITH AN ATOM THAT REALLY WANTS TO GET RID OF AN ELECTRON, THEN THEY FORM WHAT IS CALLED AN IONIC BOND. ONE OF THE MOLECULES BECOMES NEGATIVELY CHARGED (GAINED AN ELECTRON) AND THE OTHER BECOMES POSITIVELY CHARGED (LOST). TABLE SALT, OR SODIUM CHLORIDE IS LIKE THIS.



NOW, IF TWO ATOMS WHO BOTH WANT ELECTRONS THE SAME AMOUNT MEET UP, SAY TWO CARBON ATOMS, THEN THEY AGREE TO SHARE AN ELECTRON, SO THEY ESSENTIALLY BOTH GET 1. THIS IS CALLED A COVALENT BOND.



CAN I SHARE YOUR PORSCHE TOO?

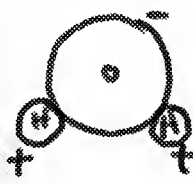
Ed. Note: Atoms don't have cars... unless it's a neon! hoooo!

OK, SAME SCENARIO, BUT THIS TIME, ONE OF THE TWO ATOMS IS KIND OF A BULLY. LIKE OXYGEN FOR INSTANCE. OXYGEN REALLY LIKES ELECTRONS, AND HYDROGEN IS KIND OF A PUSHOVER. SO EVEN THOUGH THEY ARE COVALENTLY BONDED (SHARING) THE OXYGEN HOGS THE ELECTRONS A LITTLE MORE THAN THE HYDROGENS, SO IT IS SLIGHTLY NEGATIVE, WHILE THE HYDROGENS ARE SLIGHTLY POSITIVE.

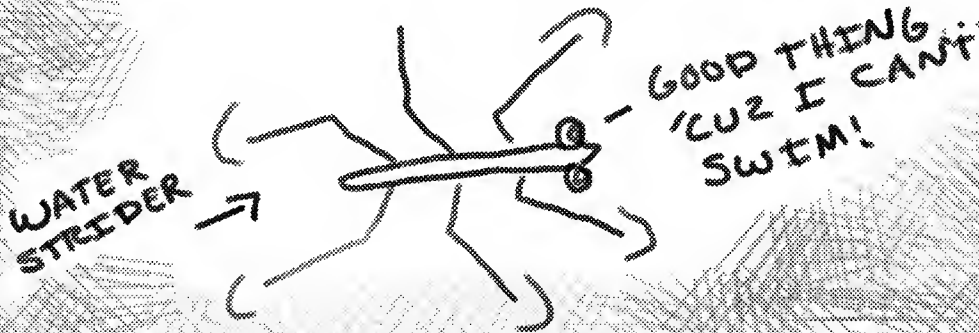


WHY IS THIS IMPORTANT? THIS LITTLE MOLECULAR BONDING QUIRK MAKES LIFE POSSIBLE. IT GIVES WATER ALL THE QUALITIES NECESSARY FOR IT TO BE THE BASIS FOR LIFE ON EARTH. LET'S LOOK CLOSER AT WATER...

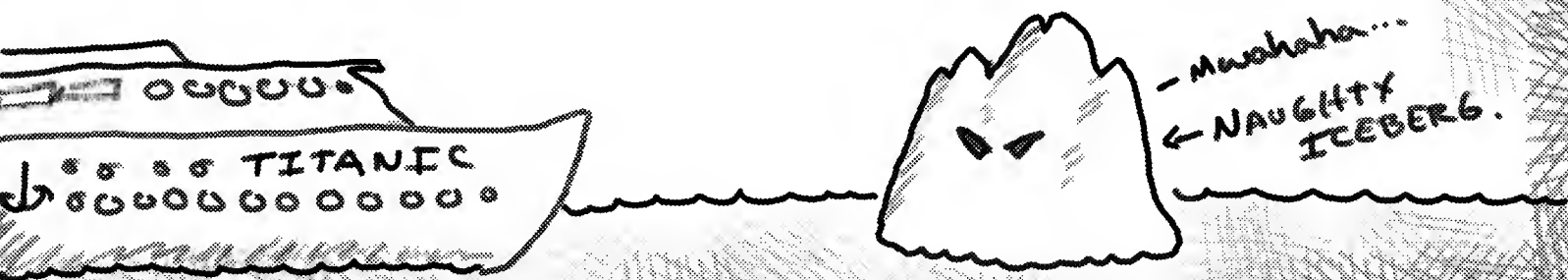
BECAUSE OF THESE SLIGHTLY POSITIVE AND SLIGHTLY NEGATIVE ENDS TO WATER, WE CALL IT A POLAR MOLECULE - AS IN IT HAS POLES, JUST LIKE A MAGNET. AND JUST LIKE MAGNETS, WATER MOLECULES STICK TOGETHER - THIS RESULTS IN QUALITIES LIKE:



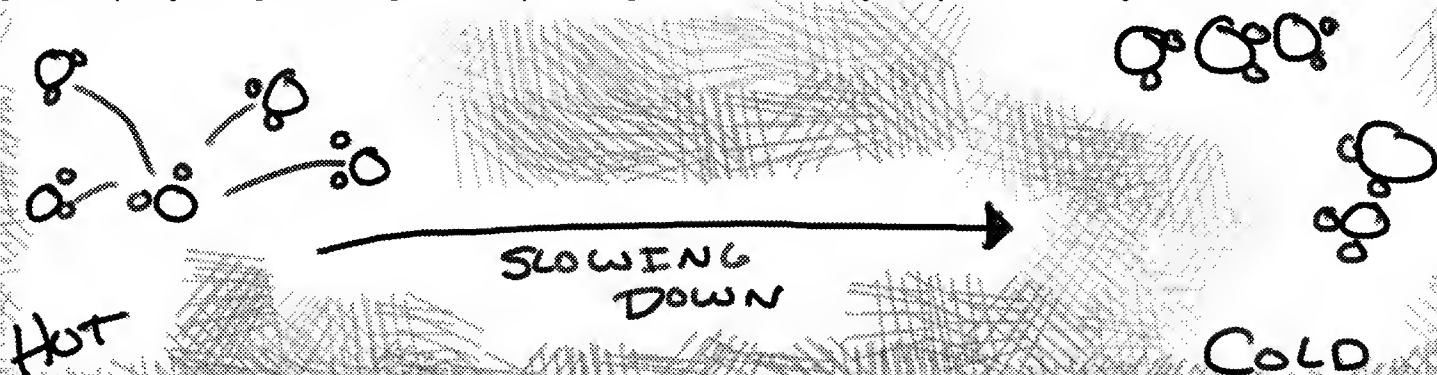
SURFACE TENSION! OR THE IDEA THAT WATER MOLECULES STICK TOGETHER - THIS IS ALSO CALLED COHESION



NOW, ORDINARILY WHEN A MOLECULE COOLS FROM A LIQUID TO A SOLID, IT BECOMES MORE DENSE (MORE WEIGHT PER VOLUME) BUT YOU KNOW FROM EXPERIENCE THAT ICE FLOATS - WHY?



AS WATER MOLECULES COOL DOWN, THEY SLOW DOWN. WHEN THEY ARE WARM (LIQUID), THEY HAVE LOTS OF ENERGY - ALTHOUGH THEY STICK TO EACH OTHER BRIEFLY, THEY QUICKLY BOUNCE BACK. BUT! AS THEY SLOW DOWN, THEY STOP BOUNCING AND START TO STICK AND STAY STUCK: POSITIVE TO NEGATIVE END.



AS MORE AND MORE WATER MOLECULES STICK TOGETHER, THEY FORM A CRYSTAL STRUCTURE (CALLED A LATTICE) THAT IS LESS DENSE THAN LIQUID WATER. THIS IS WHY ICE FLOATS! THIS IS IMPORTANT, BECAUSE WITHOUT THE INSULATING LAYER OF ICE IN THE WINTER TIME, ALL OUR LAKES AND OCEANS WOULD FREEZE SOLID. AND THAT WOULD BE A BUMMER. 'CUZ WE'D BE DEAD.



ALONG THE SAME LINES, BECAUSE OF ALL IN THE INTERACTIONS BETWEEN WATER MOLECULES, WATER HOLDS IN HEAT VERY WELL. THIS IS WHY COASTAL CITIES ALWAYS HAVE MORE MODERATE CLIMATES THAN SAY...UTAH. MORE WATER = MORE HEAT AT NIGHT AND MORE COOL IN THE DAYTIME! WITHOUT ALL OF OUR WATER ON EARTH, WE WOULD HAVE HUGE TEMPERATURE FLUCTUATIONS. THAT TOO, WOULD BE AN EARTH KILLING BUMMER.



WHY YOU...

THE LAST REASON WATER IS SO IMPORTANT IS IT DISSOLVES STUFF VERY WELL (GOOD SOLVENT)- WHICH IS IMPORTANT FOR YOUR INNER WORKINGS. YOUR BODY AND CELLS HAVE TO CONSTANTLY MOVE STUFF AROUND. WATER IS HOW WE DO IT.

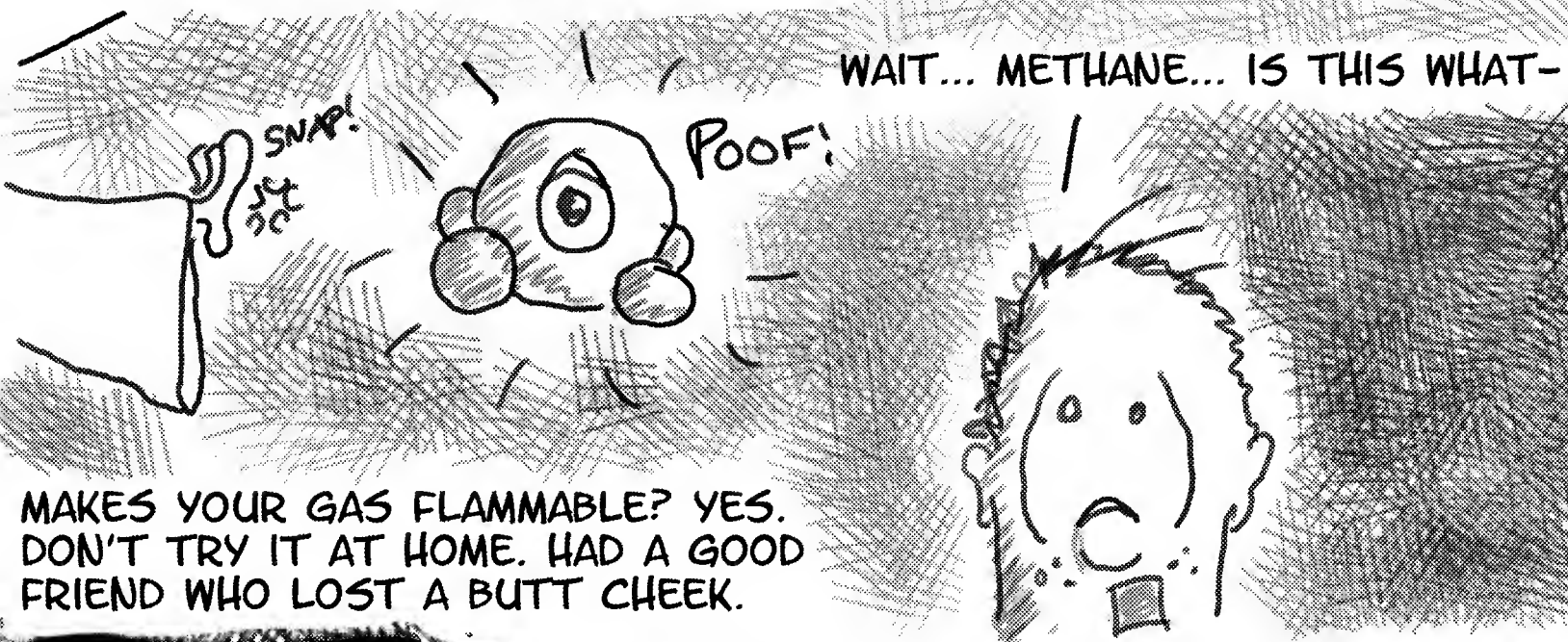


OH YEAH!



AGH!

THE LAST TYPE OF IMPORTANT MOLECULE IN BIOLOGY IS THE ORGANIC MOLECULE. IN BIOLOGY, ORGANIC SIMPLY MEANS THAT THERE ARE ONE OR MORE CARBON ATOMS IN A MOLECULE. TAKE THIS, THE SIMPLEST OF ORGANIC MOLECULES - METHANE.



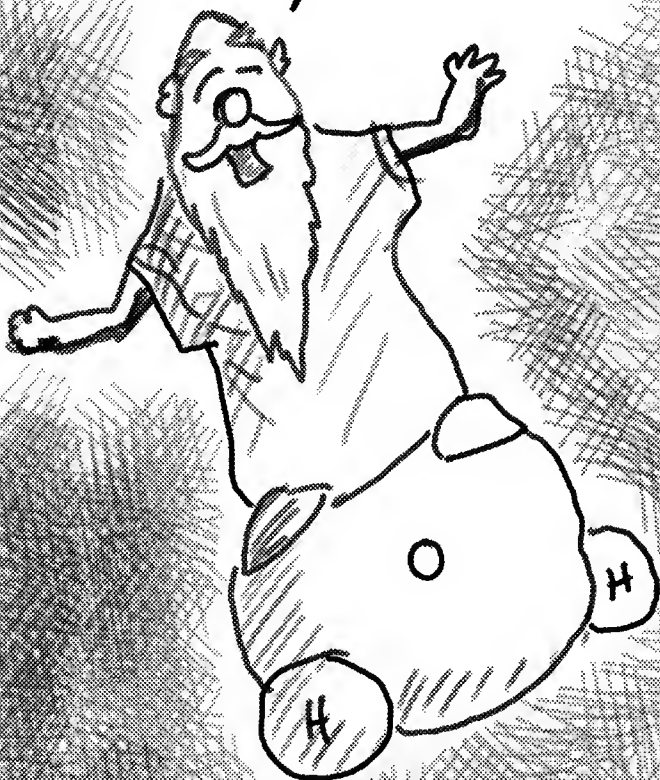
OK, WIERD. ACTUALLY I WAS GOING TO ASK IF IT WAS WHAT WE HEATED OUR HOUSES WITH



SOMETIMES, BUT USUALLY THAT IS PROPANE, IT HAS A SLIGHTLY MORE COMPLEX STRUCTURE. ANYWAY, ORGANIC = CARBON. GOT IT?



HMMM. I DON'T SEE WHY NOT.
EVERY BOY NEEDS A PET...
AHM..GAS MOLECULE, RIGHT?



I THINK I'LL NAME HIM TOOTS.

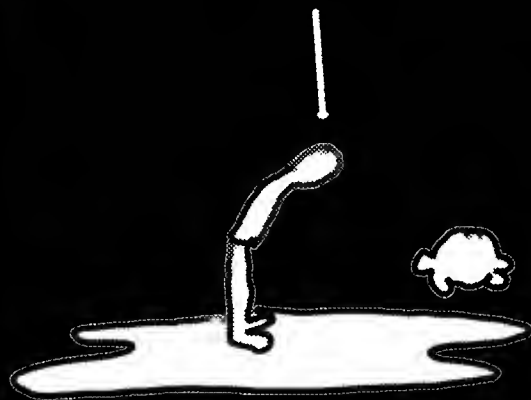


KEEP HIM AWAY FROM
OPEN FLAMES IF YOU VALUE TOOTS-
AND YOUR HAIR.

NO OPEN FLAMES. GOT IT. CAN WE
LEAVE NOW? I THREW UP MY DINNER
ALREADY, BUT I FEEL LIKE LUNCH
MAY BE FIGHTING TO COME UP TOO.



AND NOW I'M STANDING IN A
MUD PUDDLE AGAIN. THIS NIGHT
COULD NOT GET ANY INSANER.



MORE INSANE.

WHAT? YOU GONNA TUTOR
ME IN ENGLISH NOW TOO?



JUST SAYIN'. ANYWAY, WE NEED
TO GET MOVING TO GET TO CELL
CITY IN TIME.

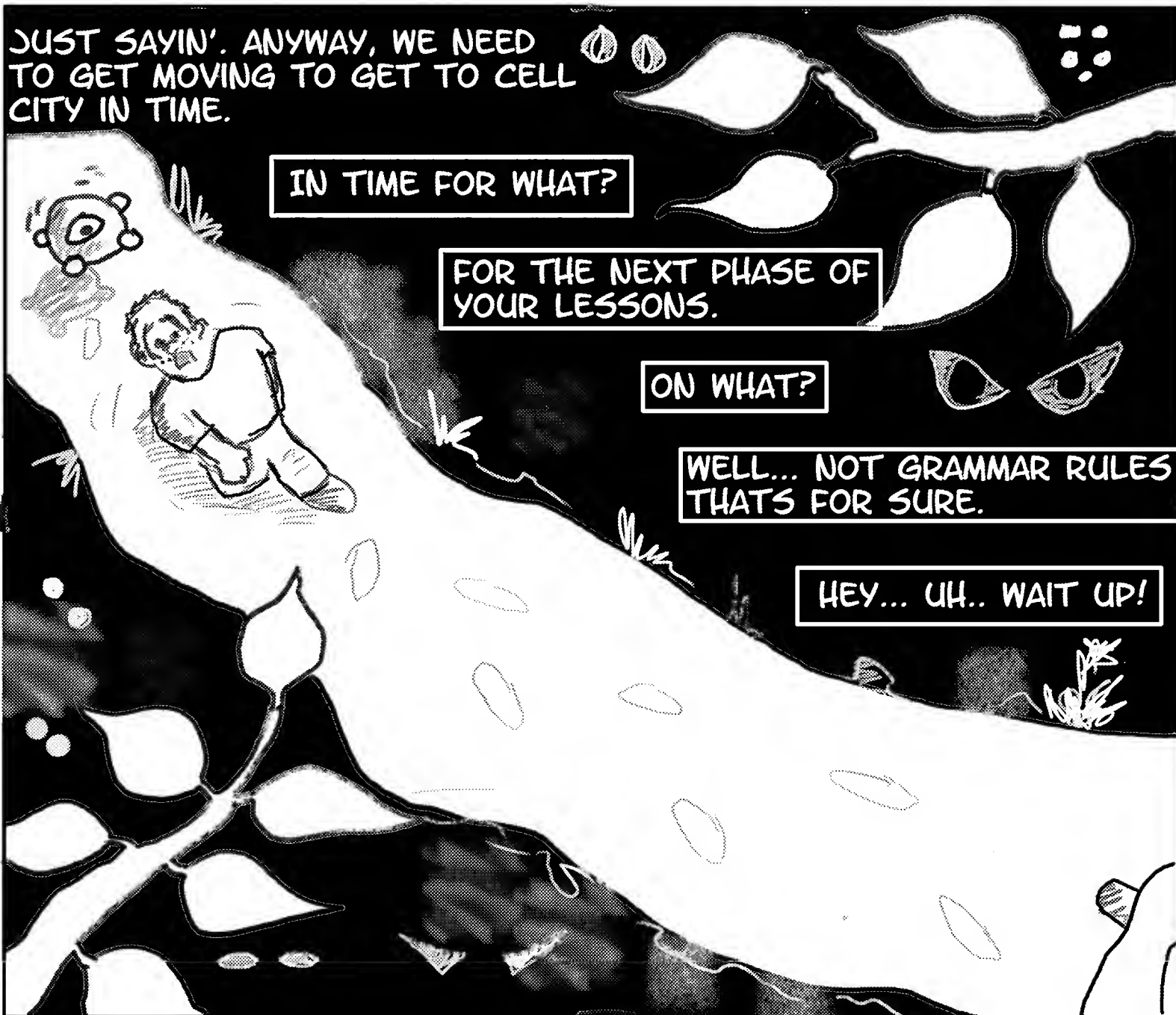
IN TIME FOR WHAT?

FOR THE NEXT PHASE OF
YOUR LESSONS.

ON WHAT?

WELL... NOT GRAMMAR RULES
THAT'S FOR SURE.

HEY... UH.. WAIT UP!

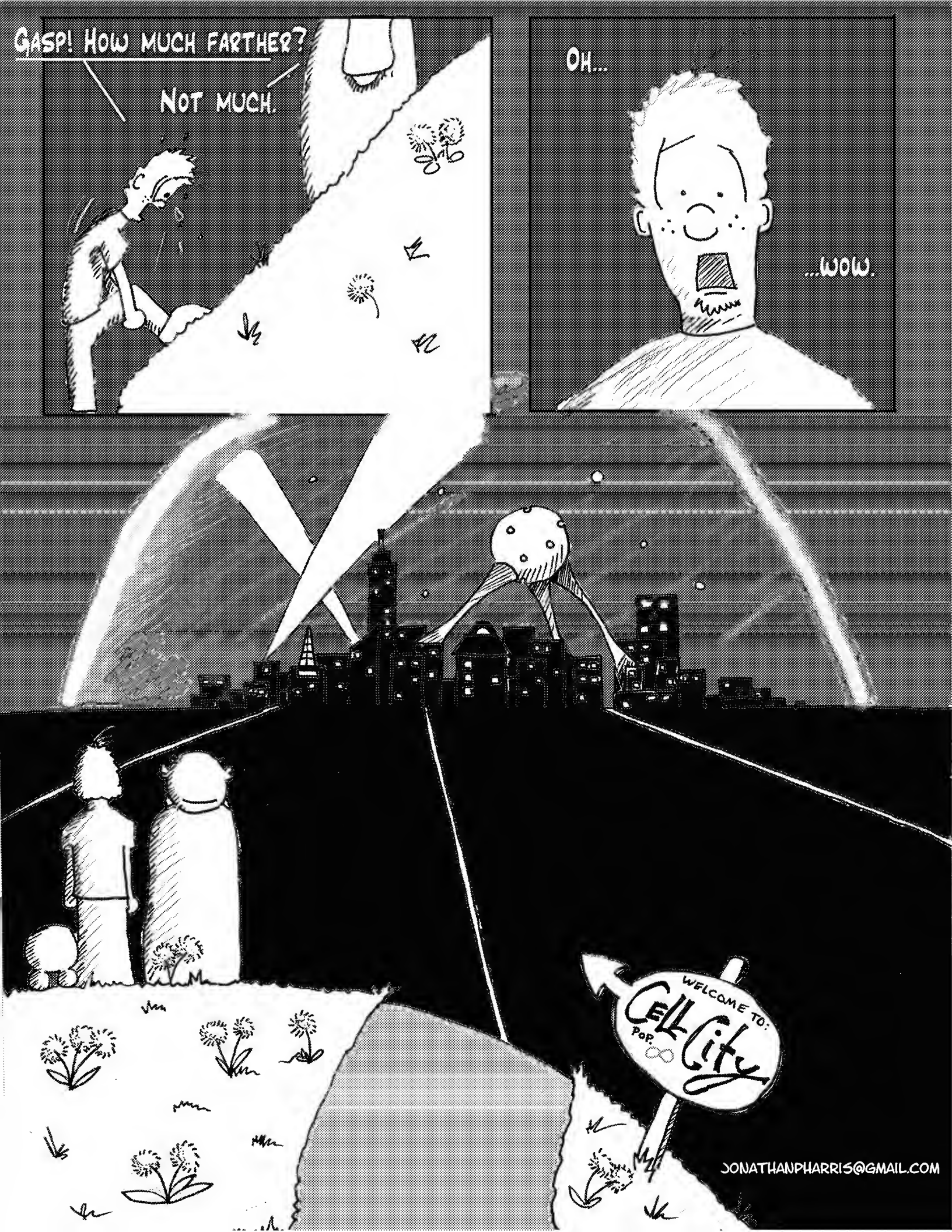


GASP! HOW MUCH FARTHER?

NOT MUCH.

OH...

...WOW.



REVIEW

1. AN ATOM, OR THE SMALLEST PART OF AN ELEMENT, IS MOSTLY EMPTY SPACE. IN FACT, IF WE MADE AN ATOM THE SIZE OF A FOOTBALL STADIUM, THE NUCLEUS WOULD BE ABOUT THE SIZE OF A MARBLE SITTING IN THE CENTER, WITH A CLOUD OF WHERE ELECTRONS MIGHT BE BUZZING AROUND IT. DRAW AN ATOM WITH 2 PROTONS AND 2 ELECTRONS BELOW. IT DOESN'T NEED TO BE TO SCALE. LABEL THE PARTS.

2. IF THE ATOMIC WEIGHT OF OUR ATOM IS 4, HOW MANY NEUTRONS WOULD WE NEED TO ADD?

3. WHAT ELEMENT HAVE WE CREATED?

4. POTASSIUM (K) HAS AN ELECTRONEGATIVITY OF .82. ELECTRONEGATIVITY IS A MEASURE OF HOW MUCH AN ELEMENT "WANTS" ELECTRONS AND RANGES FROM ABOUT .7-3.8
IF WE COMBINED POTASSIUM WITH CHLORINE (ELECTRONEGATIVITY OF 3.16), WHAT TYPE OF BOND DO YOU THINK WOULD FORM? WHY?

5. WHAT ARE 2 OF THE PROPERTIES OF WATER THAT MAKE IT SO IMPORTANT FOR LIFE? WHY DOES IT HAVE THESE PROPERTIES?